Embodiment #1 **Vertical channel guide**

Etch Via in Silicon

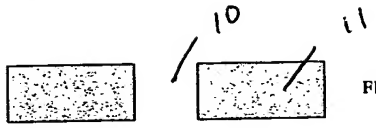

FIG. 1A

Coat Sidewall with low refractive index material to provide the function of waveguide cladding layer

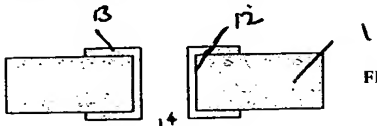

FIG. 1B

Fill the via with high refractive index material to provide the function of waveguide core layer

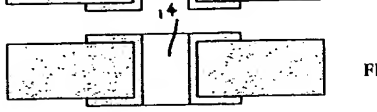

FIG. 1C

Maintain spot size through Si substrate using difference in index of refraction between core and clad layers

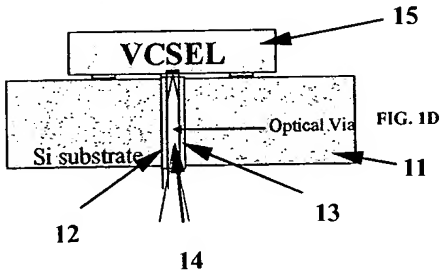

FIG. 1D

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Embodiment #2 **Vertical channel guide thru Silicon core**

Etch Vias in Silicon

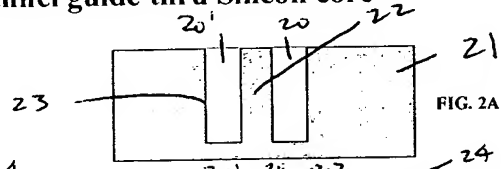


FIG. 2A

Coat Sidewall with low refractive index material to provide the function of waveguide cladding layer

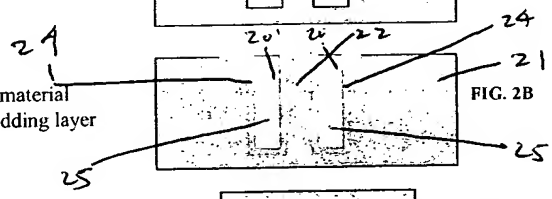


FIG. 2B

Guide the light with controlled divergence through substrate Assumes wavelength transparent in Si Clad with polymer or nitride annular ring filled with polymer

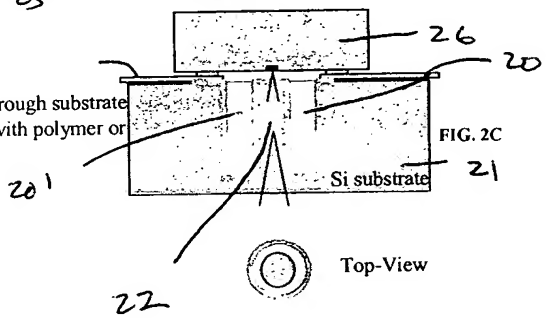


FIG. 2C

P. Chiniwalla, 2/18/03

Embodiment #3 **Electro-optical Via**

Etch Vias in Silicon

Coat Sidewall with low refractive index material to provide the function of waveguide cladding layer And electrically conductive material to provide function Of electrical conduction

Form electrical connection to the electrically conductive material

Attach device; Formed structure can carry electrical and Optical signals.

P. Chiniwalla, 2/18/03

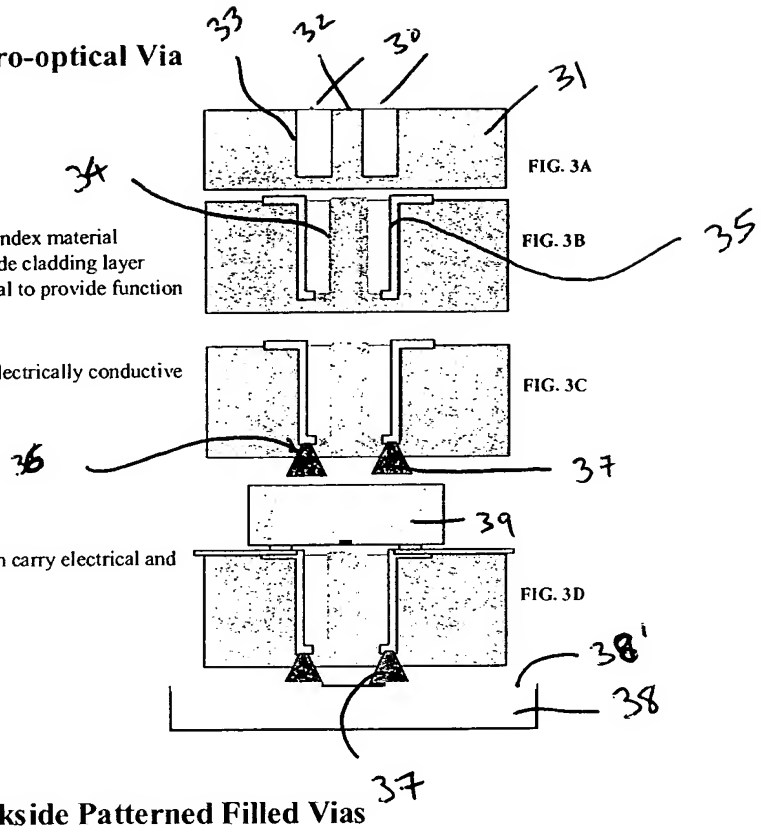


FIG. 3A

FIG. 3B

FIG. 3C

FIG. 3D

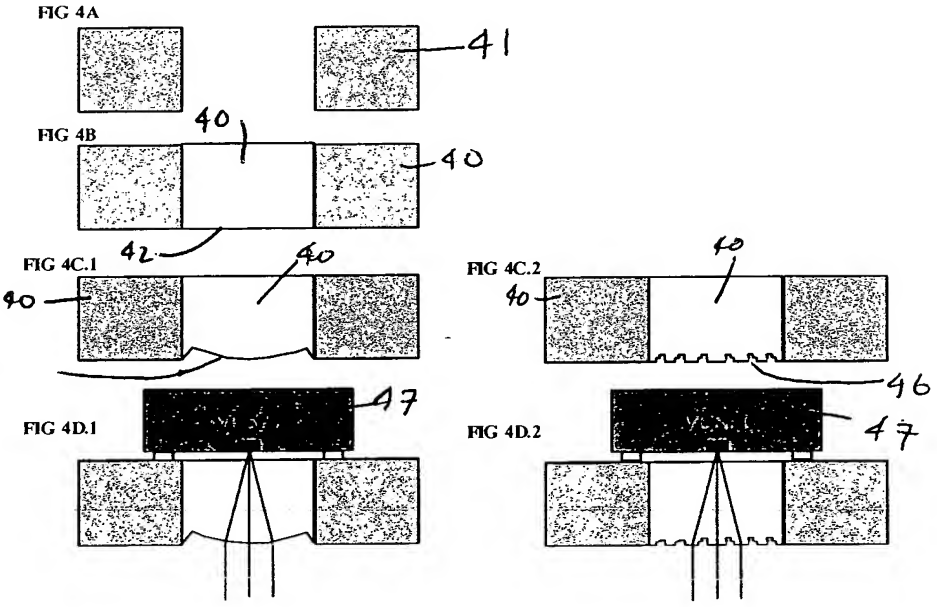
Embodiment #4: Backside Patterned Filled Vias

Etch Vias in Silicon

Fill Vias with transparent media

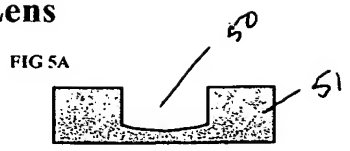
Etch the backside of the Filled Via

Etched Patterns redirect the light by refractive (e.g. lens) or diffractive (e.g. grating) optics

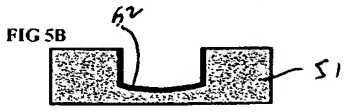


Embodiment 5: Via with Lens

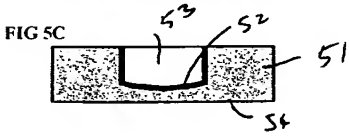
Etch Vias in Silicon



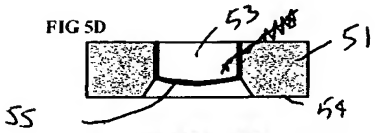
Deposit Etch Stop Layer
(e.g. Nitride Layer)



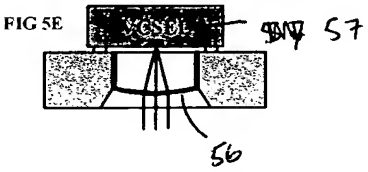
Fill with Transparent Media



Open Via by Backside Etch

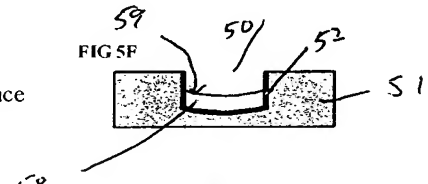


The via etch produces a
curved surface at the bottom
of the via that acts as a lens

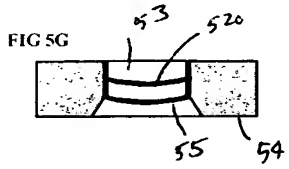


Embodiment 5: Via with Lens, alternate

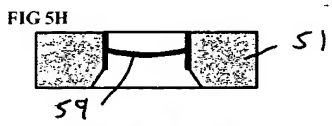
Fill With Sacrifical Material With
Appropriate Surface Tension to Produce
Lensing Miniscus (e.g. organic)



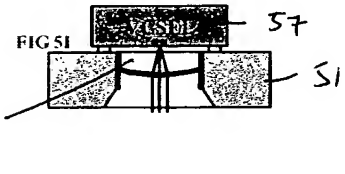
Deposit Etch Stop (e.g. Nitride),
Fill with Transparent Media,
Open Via with Backside Etch



Remove Etch Stop Layer,
Remove Sacrificial Material



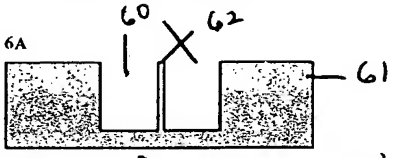
The curved surface formed by the
miniscus acts as a lens



Embodiment #6: Discrete Index Gradient Guiding Pillar, for wavelength >1 μm

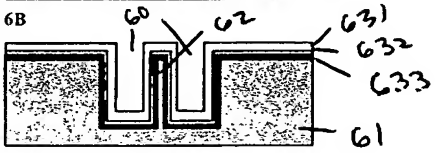
Etch Annular Ring in Silicon, small diameter center post (e.g.. 5 μm)

FIG 6A



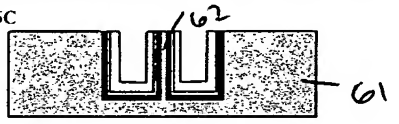
Sequentially deposit layers with decreasing index with until diameter is larger enough to capture all of the light

FIG 6B



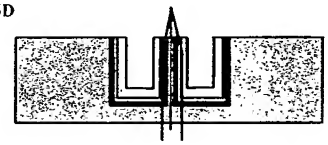
Planarize Top Layer

FIG 6C



Light will be guided down the small diameter silicon core by the index gradient produced in the layers

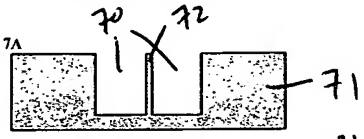
FIG 6D



Embodiment #7: Discrete Index Gradient Support Pillar, intended for wavelength < 1 μm

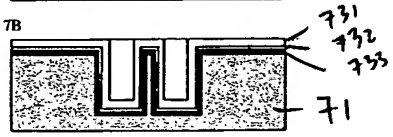
Etch Annular Ring in Silicon, small diameter center post (e.g.. 5 μm)

FIG 7A



Sequentially deposit layers until diameter is larger enough to capture all of the light, Fill remaining cavity with low index material

FIG 7B



Planarize Top Layer

FIG 7C

Planarize Bottom Layer

FIG 7D

Light will be guided down the high index ring by the index gradient produced in the layers. The silicon will obstruct only a small fraction off the as it is small relative to rest of the light guiding layers

FIG 7E

Index Profile of each layer deposited relative to the center silicon post

FIG 7F

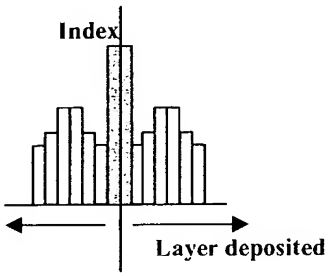


FIG. 8 Carrier with Integrated Gradient Index Microlenses

FIG. 8 Carrier with Integrated Gradient Index Microlenses

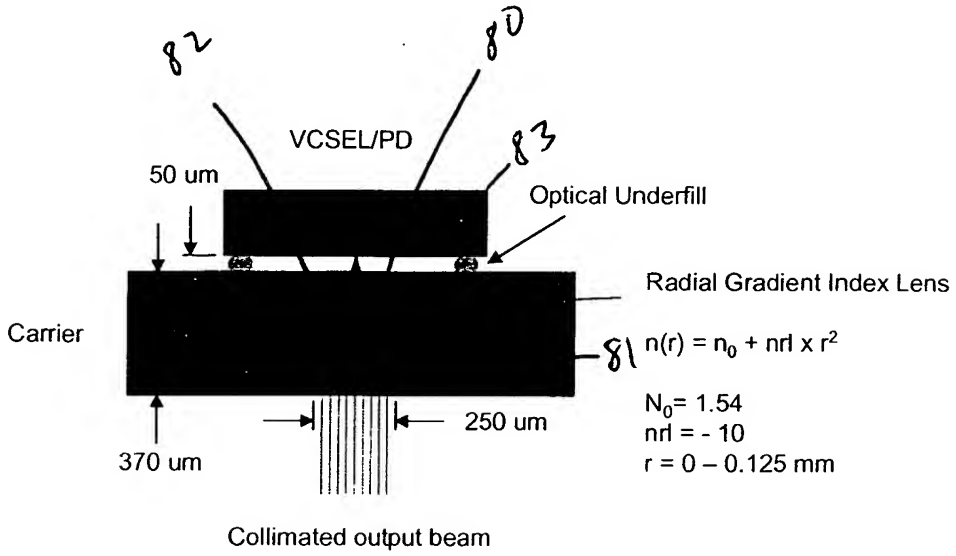
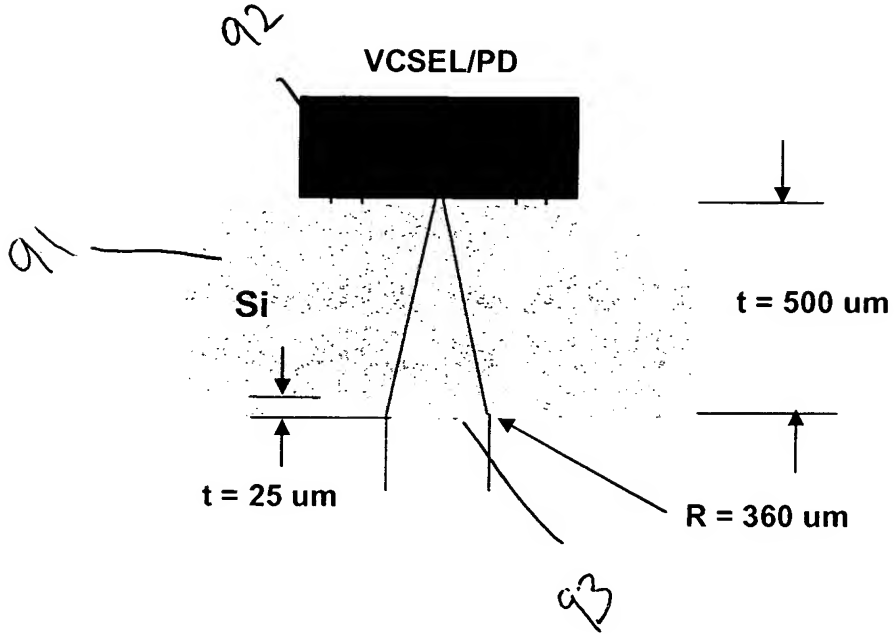


FIG. 9 Lens Etched into Backside of Si Carrier



Embodiment #10 Carriers with Attached Microlens Arrays

FIG. 10a

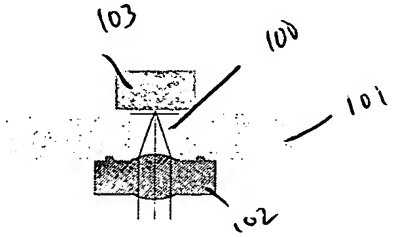


FIG. 10b

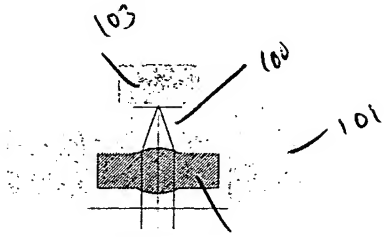


FIG. 10c

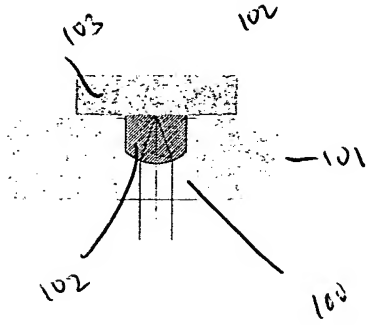


FIG. 10d

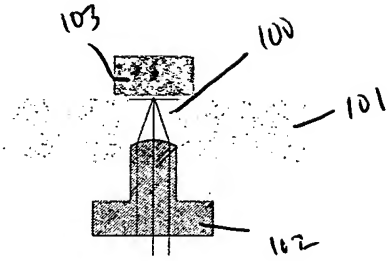


FIG. 10e

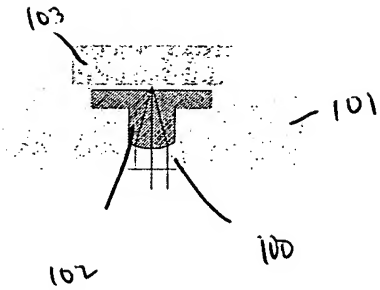


FIG. 11 Typical Use

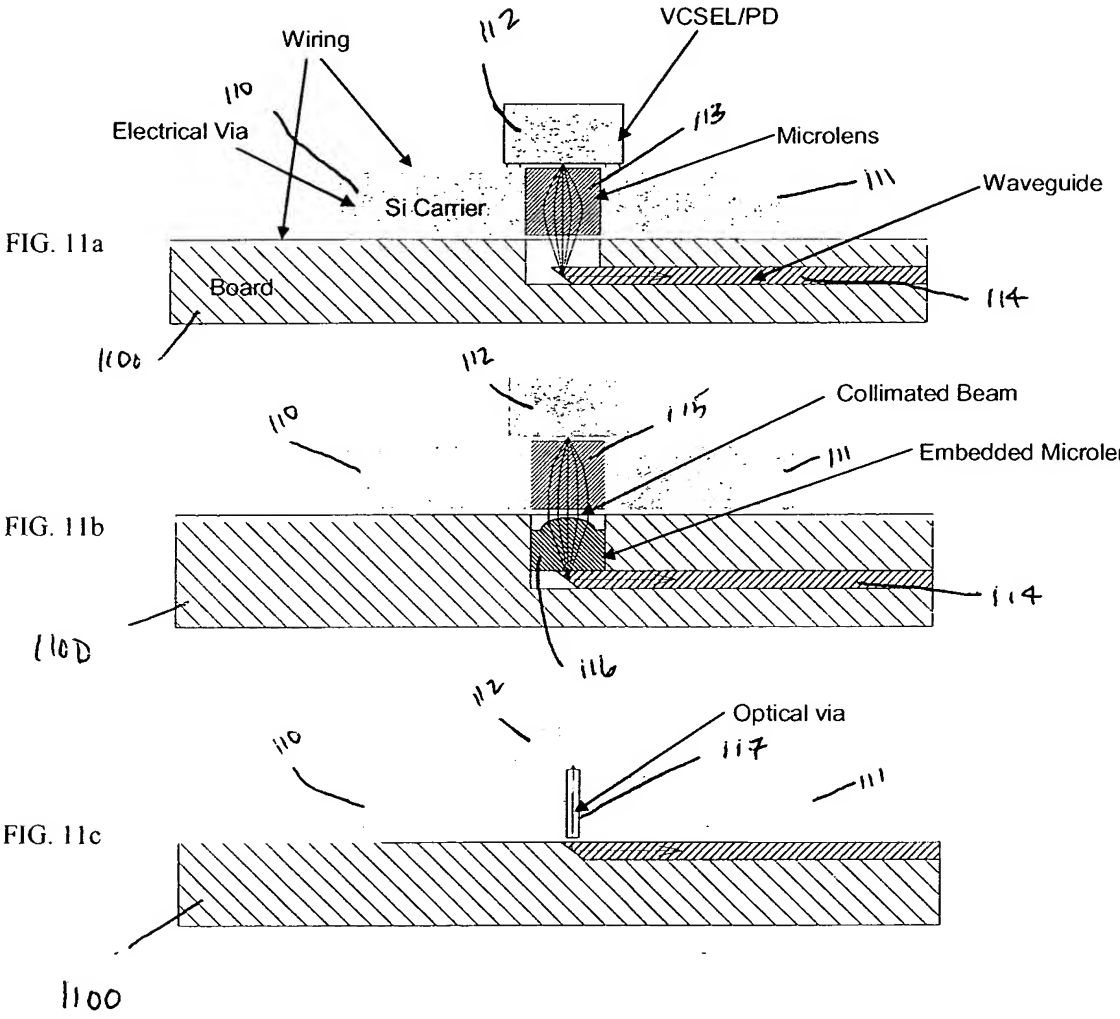


FIG. 11a

FIG. 11b

FIG. 11c